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(54) **OPENING AND CLOSING MEMBER CONTROL APPARATUS AND METHOD FOR CONTROLLING OPENING AND CLOSING MEMBER**

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E05F 15/00 (2015.01)
E05F 15/40 (2015.01)

(52) **U.S. Cl.**

CPC ***E05F 15/0004*** (2013.01); ***E05F 15/40*** (2015.01); *E05Y 2900/50* (2013.01)

(58) **Field of Classification Search**

CPC E05Y 2900/50; E05F 15/40; E05F 15/004
USPC 49/26, 28, 348, 349, 350, 351, 502, 49/506; 318/264, 266, 267, 466, 480, 54, 318/467, 283, 434, 286
See application file for complete search history.

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(57) **ABSTRACT**

An open-close member control apparatus has a function to release a foreign matter pinched to an open-close member. The open-close member is either (i) driven only while a manipulation switch is manipulated or (ii) driven continuously once the manipulation switch is manipulated to a specified position regardless of whether the manipulation is then released. When trapping of a foreign matter is detected under an open movement of the open-close member to an open direction based on an open command signal from the manipulation switch, an electric power supply to a motor is restricted to stop a progress of the trapping. When receiving a close command signal from the manipulation switch after restricting the electric power supply, the electric power is supplied to the motor to drive the open-close member to a close direction under a restricted state of a predetermined operation.

8 Claims, 9 Drawing Sheets

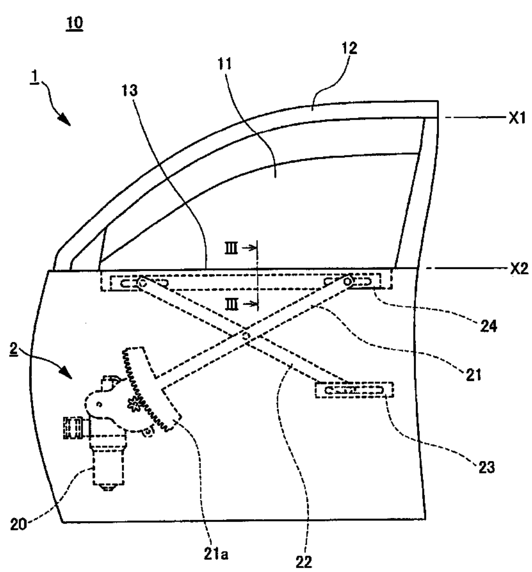


FIG. 1

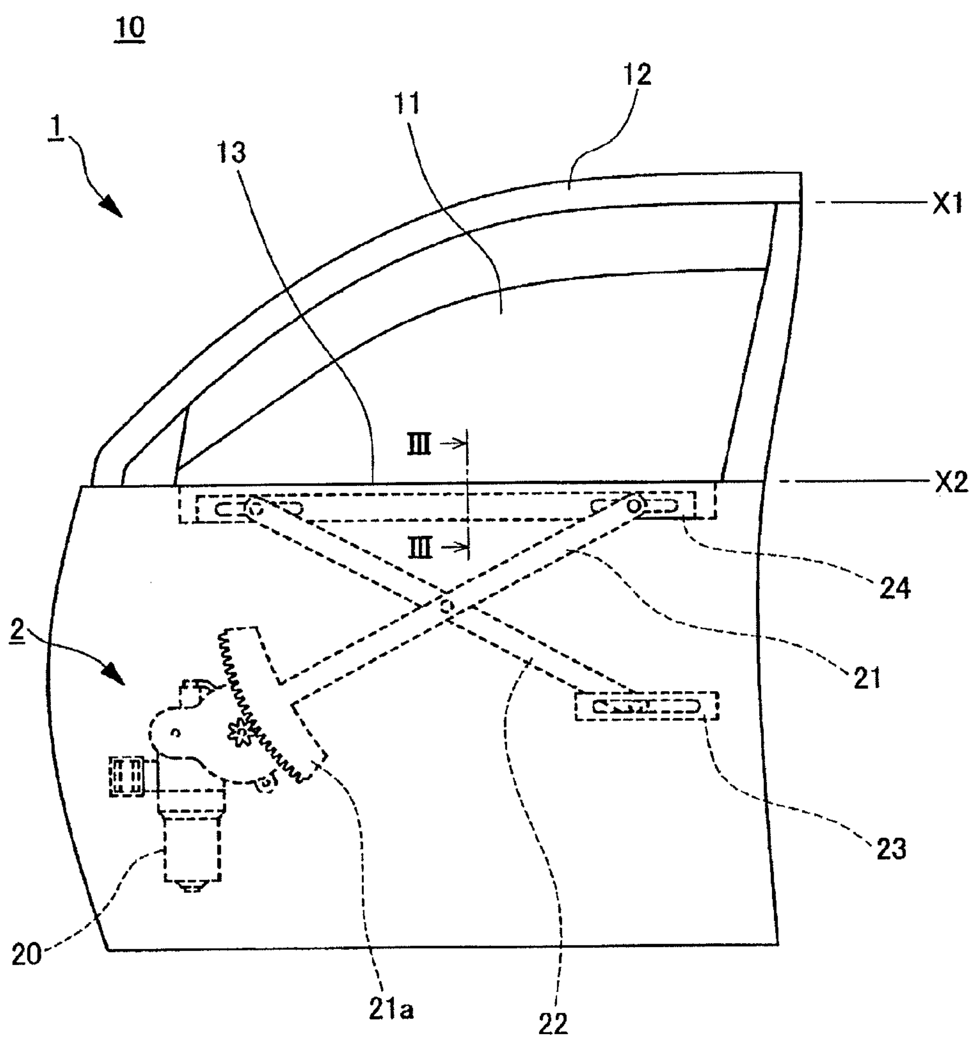


FIG. 2

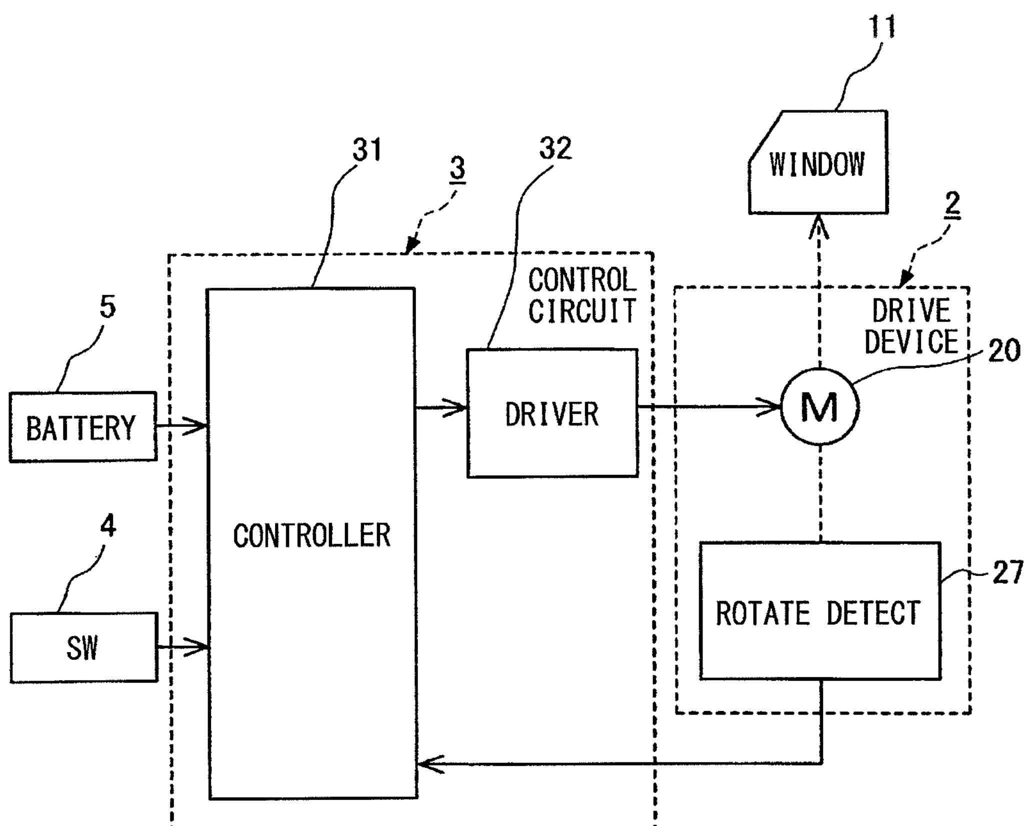

11
WINDOW
31
3
32
CONTROL
CIRCUIT
2
DRIVE
DEVICE
20
5
BATTERY
DRIVER
M
CONTROLLER
4
SW
ROTATE DETECT
27

FIG. 3

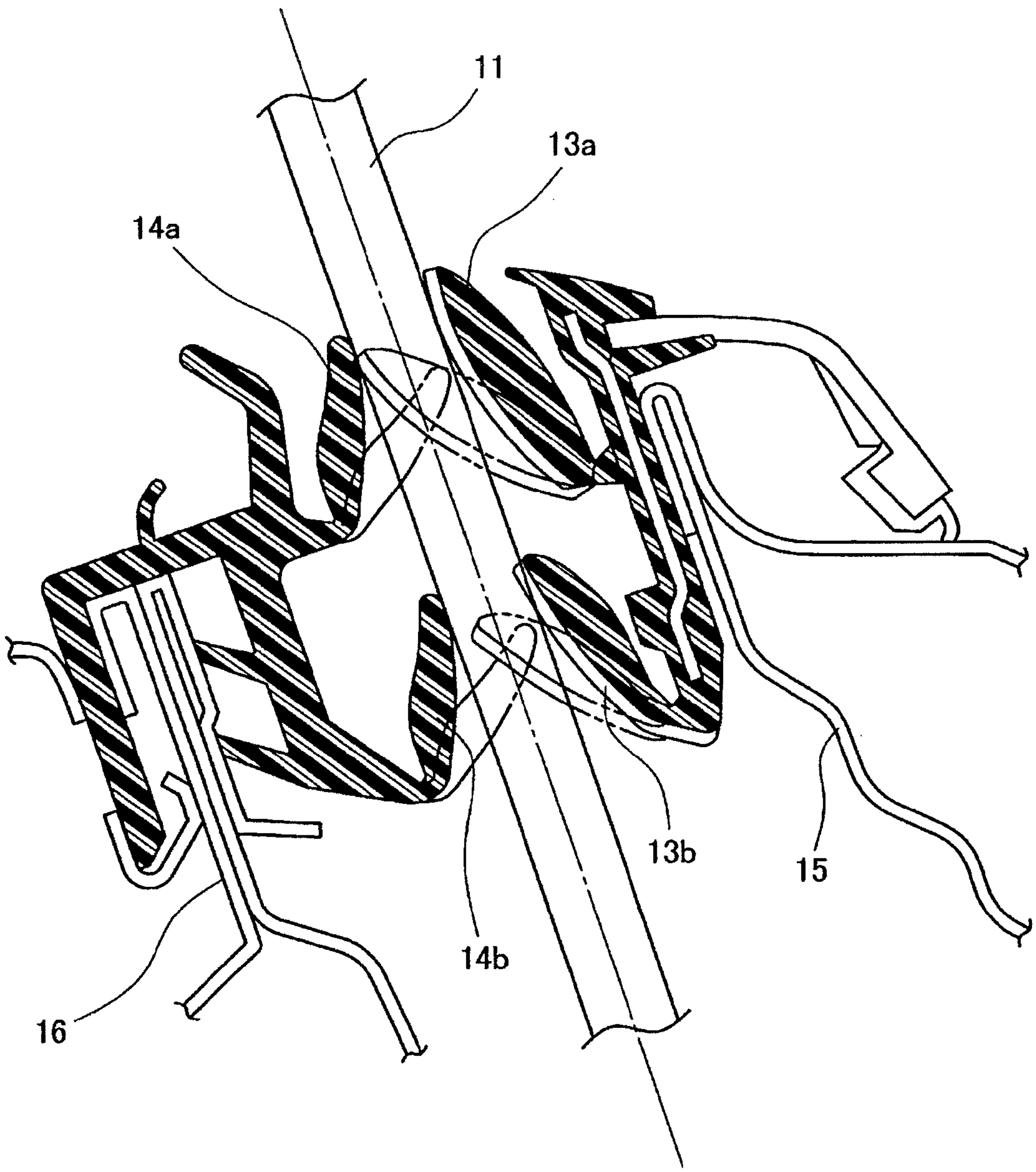


FIG. 4A

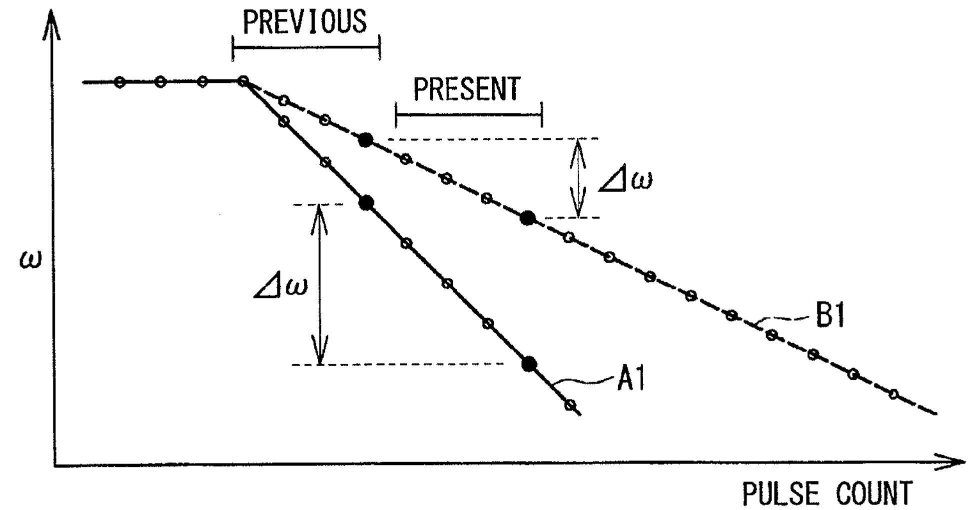


FIG. 4B

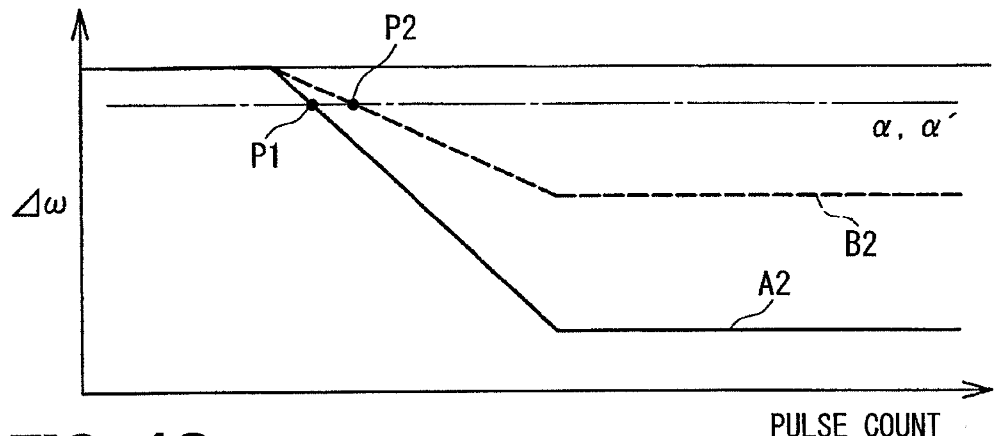


FIG. 4C

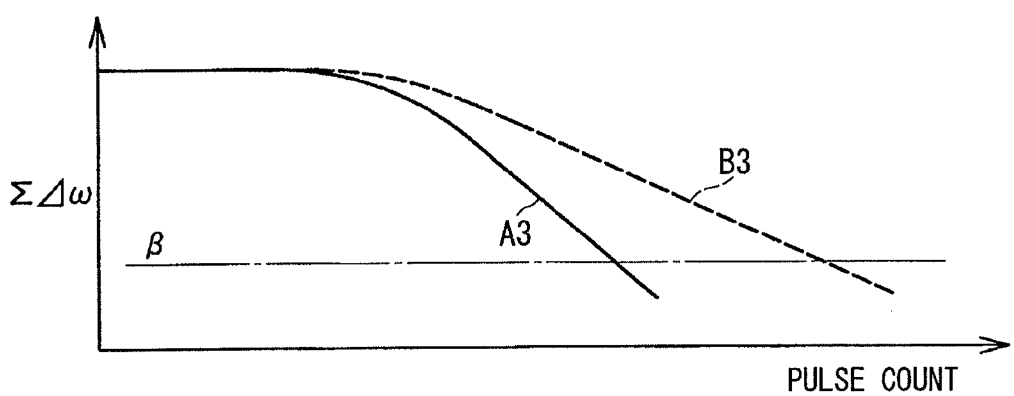


FIG. 5

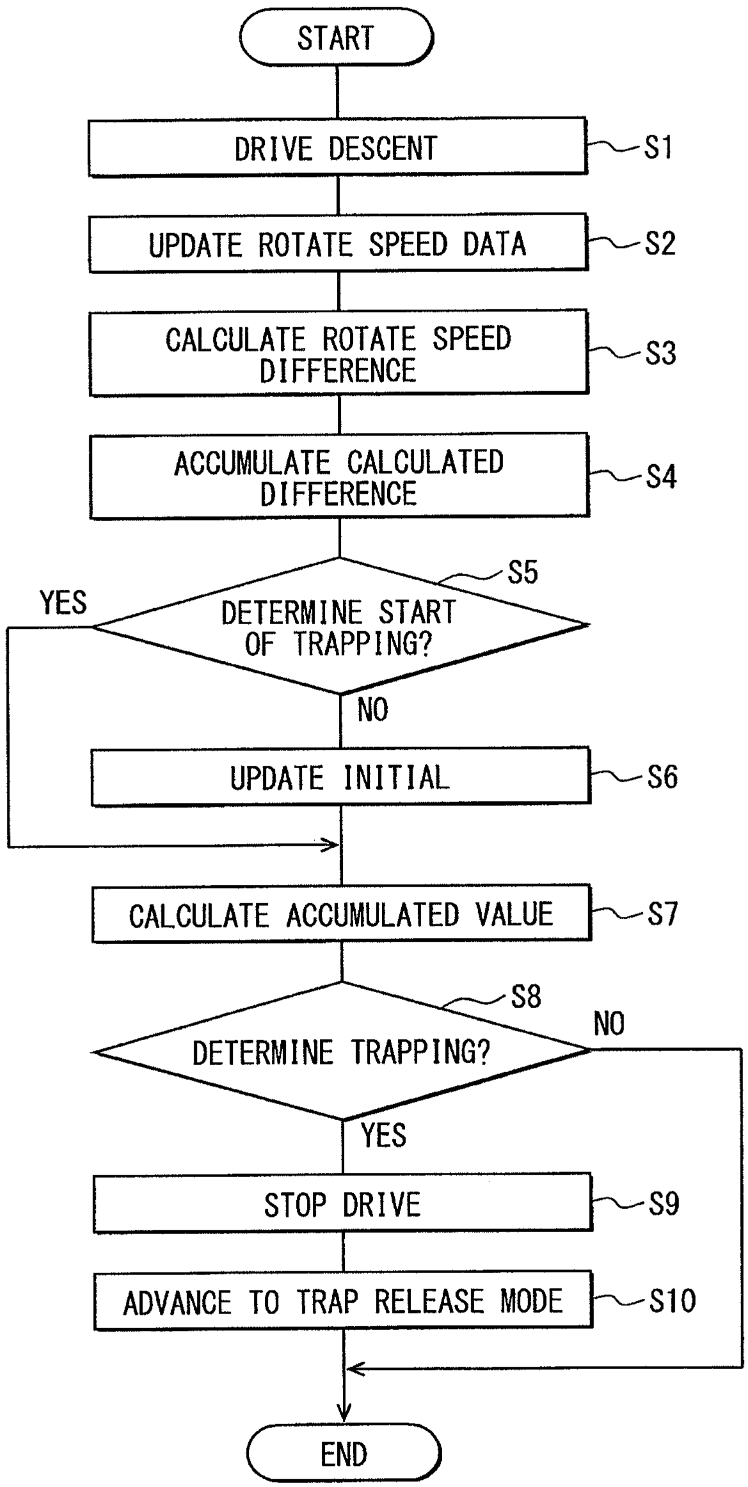
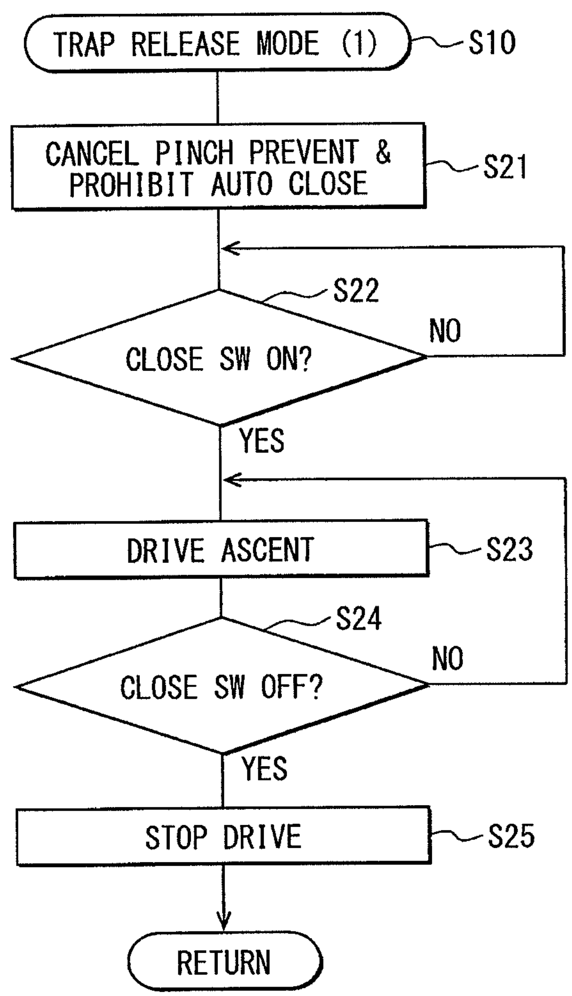
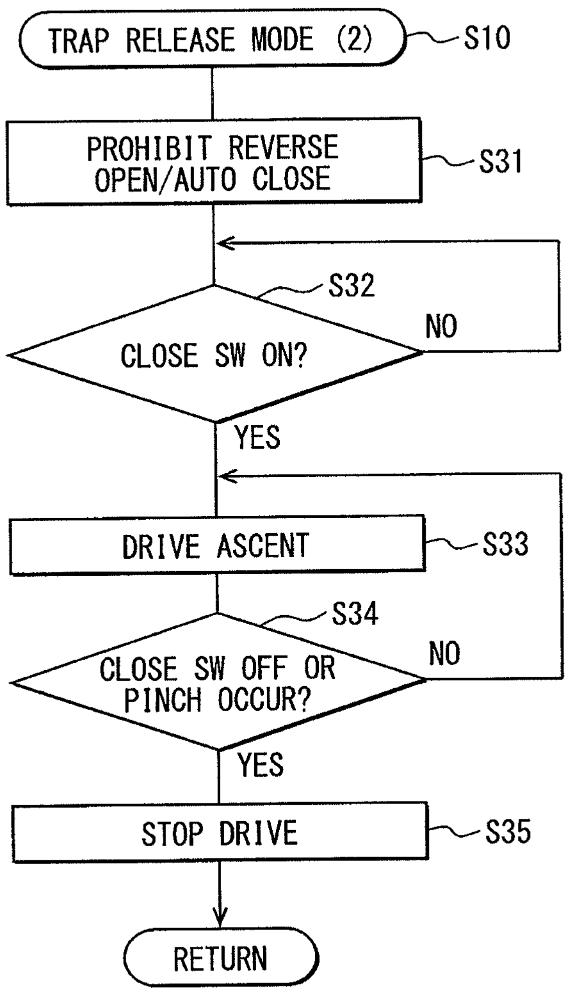

START
DRIVE DESCENT
S1
UPDATE ROTATE SPEED DATA
S2
CALCULATE ROTATE SPEED DIFFERENCE
S3
ACCUMULATE CALCULATED DIFFERENCE
S4
DETERMINE START OF TRAPPING?
S5
YES
NO
UPDATE INITIAL
S6
CALCULATE ACCUMULATED VALUE
S7
DETERMINE TRAPPING?
S8
NO
YES
STOP DRIVE
S9
ADVANCE TO TRAP RELEASE MODE
S10
END

FIG. 6



TRAP RELEASE MODE (1)
S10
CANCEL PINCH PREVENT & PROHIBIT AUTO CLOSE
S21
S22
CLOSE SW ON?
NO
YES
DRIVE ASCENT
S23
S24
CLOSE SW OFF?
NO
YES
STOP DRIVE
S25
RETURN

FIG. 7



TRAP RELEASE MODE (2)
S10
PROHIBIT REVERSE OPEN/AUTO CLOSE
S31
S32
CLOSE SW ON?
NO
YES
DRIVE ASCENT
S33
S34
CLOSE SW OFF OR PINCH OCCUR?
NO
YES
STOP DRIVE
S35
RETURN

FIG. 8

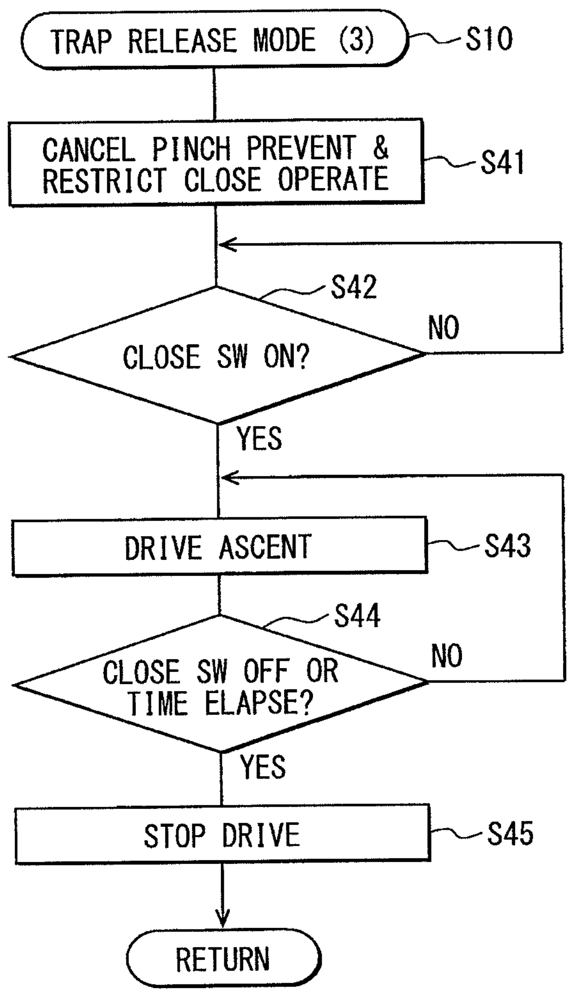
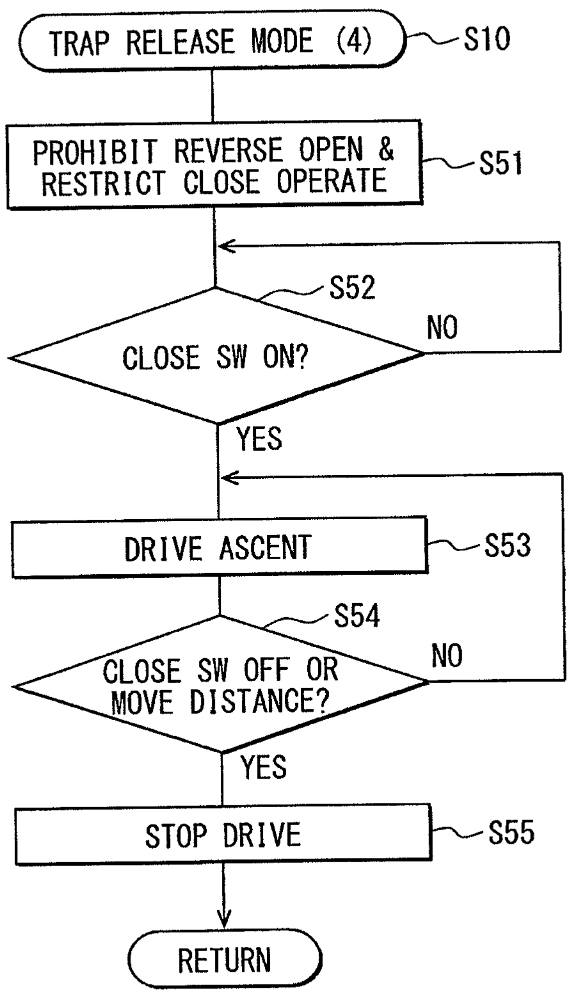

TRAP RELEASE MODE (3)
S10
CANCEL PINCH PREVENT & RESTRICT CLOSE OPERATE
S41
S42
CLOSE SW ON?
NO
YES
DRIVE ASCENT
S43
S44
CLOSE SW OFF OR TIME ELAPSE?
NO
YES
STOP DRIVE
S45
RETURN

FIG. 9



TRAP RELEASE MODE (4)
S10
PROHIBIT REVERSE OPEN & RESTRICT CLOSE OPERATE
S51
S52
CLOSE SW ON?
NO
YES
DRIVE ASCENT
S53
S54
CLOSE SW OFF OR MOVE DISTANCE?
NO
YES
STOP DRIVE
S55
RETURN

OPENING AND CLOSING MEMBER CONTROL APPARATUS AND METHOD FOR CONTROLLING OPENING AND CLOSING MEMBER

CROSS REFERENCE TO RELATED APPLICATION

The present application is based on Japanese Patent Application No. 2012-208543 filed on Sep. 21, 2012, the disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates to an open-close member control apparatus and a method for controlling an open-close member; in particular, the apparatus and the method are suitably applied in a vehicle to release a foreign matter, which is trapped between a window glass serving as the open-close member and a belt molding serving as a container of the open-close member in cases that the window glass is driven to an open direction or to descend.

BACKGROUND ART

Patent Literature 1: JP 2007-9573 A

Patent Literature 2: JP 2011-122369 A

There are conventionally known in-vehicle power window apparatuses which have a function to prevent a foreign matter being pinched when a widow glass is closed (or window glass ascends) (for example, refer to Patent Literature 1). Such a pinching prevention function of the power window apparatus detects a foreign matter, which is pinched when the window glass is driven to a close direction, and then drives a motor reversely to drive the window glass reversely.

In Patent Literature 1, in contrast, the power window apparatus does not have a function to prevent a foregoing matter that is trapped when the window glass is driven to an open direction. For instance, when the belt molding itself is trapped by the window glass, a load larger than usual is added to the motor. In this case, if the motor is operated continuously as it is, the motor may suffer a damage to produce unusual sound and lower the operating speed. In addition, if a foreign matter is trapped in between the belt molding and the window glass, the foreign matter may be damaged.

In contrast, when a trapping occurs in between the window glass and the belt molding, the window glass may be driven to ascend simply. However, in such a case, a usual pinching may occur in between the window glass and the upper portion of the window frame. To solve such a state, when a trapping is detected, the driving of the motor may be stopped or the motor may be operated to close the window glass (refer to Patent Literature 2).

While the technology in Patent Literature 2 may be effective in preventing trapping, another requirement or desire is presented which permits an occupant to release the trapping while confirming the situation. In addition, a system having a pinching prevention function but not a trapping prevention function may pose the following situation. That is, when a trapping of an arm arises, an occupant may operate the window glass to be closed or be moved up. Such a case may change a load to the trapped member to activate the pinching prevention function erroneously, thereby causing a reverse movement to open or lower the window glass and then causing a trapping again.

SUMMARY

It is an object of the present disclosure to provide an open-close member control apparatus and a method for controlling

an open-close member. In the apparatus and the method, after a trapping of a foreign matter is detected during an open movement of a window glass serving as the open-close member and then drive of a motor is stopped, an occupant is permitted to release the trapping while confirming a situation of the trapping.

It is another object of the present disclosure to provide an open-close member control apparatus with a pinching prevention function and a method for controlling the same; the apparatus and the method prevent re-occurrence of trapping due to an erroneous operation of the pinching prevention function following an occurrence of trapping.

To achieve the above object, according to an aspect of the present disclosure, an open-close member control apparatus including an open-close member and having a function to release a foreign matter pinched to the open-close member is provided to include a driving motor a control circuit; a manipulation switch; an operating state detection section; a trapping detection section; and a pinching detection section. The driving motor drives the open-close member to an open direction or a close direction. The control circuit controls operation of the driving motor. The manipulation switch outputs an open command signal or a close command signal to the control circuit, the open command signal indicating driving of the open-close member to the open direction, the close command signal indicating driving of the open-close member to the close direction. The open-close member is either (i) driven only while the manipulation switch is manipulated or (ii) driven continuously once the manipulation switch is manipulated to a specified position regardless of whether the manipulation switch having been manipulated to the specified position is then released. The operating state detection section outputs an operating state detection signal according to an operating state of the open-close member that is driven to the open direction or the close direction by the driving motor. The trapping detection section performs a trapping detection to detect a trapping of a foreign matter to the open-close member based on the operating state detection signal. The pinching detection section performs a pinching detection to detect a pinching of a foreign matter to the open-close member based on the operating state detection signal. The control circuit is further configured to (i) restrict supplying an electric power to the driving motor to stop a progress of a trapping of a foreign matter to the open-close member when the trapping detection section detects the trapping under an open movement of the open-close member to the open direction, the open movement having been started based on the open command signal from the manipulation switch, and (ii) supply the electric power to the driving motor to drive the open-close member to the close direction under a restricted state when receiving the close command signal from the manipulation switch after restricting supplying the electric power, the restricted state restricting a predetermined operation.

According to another aspect of the present disclosure, a method is provided for controlling an open-close member in the open-close member control apparatus according to the above aspect, the apparatus having a function to release a foreign matter pinched to the open-close member. The method is executed by the control circuit of the apparatus and includes the following: (i) restricting supplying an electric power to the driving motor to stop a progress of a trapping of a foreign matter to the open-close member when the trapping detection section detects the trapping under an open movement of the open-close member to the open direction, the open movement having been started based on the open command signal from the manipulation switch; and (ii) supplying the electric power to the driving motor to drive the open-close member to the close direction under a restricted state when receiving the close command signal from the manipulation switch after restricting supplying the electric power, the restricted state restricting a predetermined operation.

Under the above apparatus or the method, when a trapping of a foreign matter to the open-close member is detected during the open movement started based on the open command signal from the manipulation switch, the electric power supply to the driving motor is restricted so as to stop the progress of the trapping to the open-close member. This permits stopping the progress of the trapping of the foreign matter during the open movement (descent) of a window glass serving as the open-close member. When thereafter receiving the close command signal from the manipulation switch, the electric power supply to the driving motor is started so as to drive the open-close member to the close direction under a restricted state of a predetermined operation. This permits an occupant to release the trapping while confirming the situation without depending on an automatic trapping release function. In addition, suitably specifying the restricted predetermined operation can avoid an erroneous operation of the pinching prevention function at the time of releasing the trapping. Furthermore, stopping the progress of the trapping simultaneously prevents (i) a damage of the foreign matter due to the progress of the trapping, and (ii) another anomaly in the apparatus such as unusual sound generation or movement speed decline.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features, and advantages of the present disclosure will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

FIG. **1** is a diagram illustrating a configuration of an open-close member control apparatus according to an embodiment of the present disclosure;

FIG. **2** is an electric block diagram of the open-close member control apparatus;

FIG. **3** is a cross-sectional diagram taken from line III-III in FIG. **1**;

FIGS. **4**A, **4**B, **4**C are diagrams for explaining trapping determination;

FIG. **5** is a flowchart diagram of a trapping determination process;

FIG. **6** is a flowchart diagram of a first example of a process of a trapping release mode;

FIG. **7** is a flowchart diagram of a second example of a process of a trapping release mode;

FIG. **8** is a flowchart diagram of a third example of a process of a trapping release mode; and

FIG. **9** is a flowchart diagram of a fourth example of a process of a trapping release mode.

DETAILED DESCRIPTION

An embodiment according to the present disclosure will be explained with reference to drawings.

The following will explain a power window apparatus **1** as an open-close member control apparatus in a vehicle (also referred to as a host vehicle) according to an embodiment of the present disclosure. Refer to FIGS. **1**, **2**, and **3**. The power window apparatus **1** includes a drive device **2** to drive opening and closing of an open-close member, a control circuit **3** to control the drive device **2**, and a manipulation switch **4** for an occupant to input a command. That is, the apparatus **1** operates ascent and descent (open and close) of a window glass **11** serving as the open-close member disposed in a door **10** of the vehicle by rotation drive of a driving motor **20** included in the drive device **2**.

The door **10** has an storage space (i.e., container) in a lower portion of the door **10** (i.e., under a beltline of the vehicle) to store the window glass **11** which is lowered; the storage space is provided between an outer panel **15** arranged on a vehicle exterior side (an outside of the vehicle in a width direction) and an inner panel **16** arranged on a vehicle interior side (an inside of the vehicle in the width direction). The door **10** has a window frame (glass frame) **12** in an upper portion; the window glass **11** is heightened or ascends beyond a lower frame portion of the window frame **12** to thereby appear from the storage space into an inside area of the window frame **12**, thereby undergoing open-close or descent-ascent (up-down) movement.

The lower frame portion of the window frame **12** is provided with belt moldings **13** and **14** as a sealing member. The belt molding includes an outer molding **13** and an inner molding **14**. The outer molding **13** is fixed to an upper portion of the outer panel **15**; the inner molding **14** is fixed to an upper portion of the inner panel **16**.

The window glass **11** passes or moves through a gap between the outer molding **13** and the inner molding **14**, and undergoes an up-down movement (i.e., close movement and open movement) inside of the window frame **12**. The outer molding **13** and the inner molding **14** include seal projections **13***a*, **13***b*, **14***a*, **14***b* projected to the window glass **11**, respectively; these seal projections **13***a*, **13***b*, **14***a*, **14***b* are elastically press-fitted to glass surfaces of the window glass **11**. Thus, the belt moldings **13**, **14** may be also referred to as a storage portion or container.

In addition, the upper frame portion of the window frame **12** is similarly provided with a weather strip (i.e., upper molding) as a sealing member (unshown). The weather strip is provided with a groove that opens downwardly. The groove is formed to accommodate or receive an uppermost end of the window glass **11** by a predetermined length. The glass surface of the received uppermost end of the window glass **11** is press-fitted to the inner wall of the groove.

In the present embodiment, the window glass **11** undergoes an up-down movement of moving (i.e., ascending and descending) between a high fully-closed position X1 (uppermost end) and a low fully-opened position X2 (downmost end) according a predetermined rule. With reference to FIG. **1**, the drive device **2** of the present embodiment includes the driving motor **20** (hereinafter, also referred to as a motor **20**) and a driving mechanism. The motor **20** is fixed to the door **10** and has a deceleration mechanism. The driving mechanism includes an up-down arm **21** equipped with a fan-shaped or sector-shaped gear **21***a* driven by the motor **20**; a driven arm **22** pivotally intersecting with the up-down arm **21**; a fixed channel **23** fixed to the door **10**; and a glass-side channel **24** integrated with the window glass **11**.

The motor **20** receives an electric power supply from the control circuit **3**; the winding of the rotator of the motor **20** receives electric current. This generates a magnetic attraction function between the rotator and a stator having a magnet, permitting forward and reverse rotation of the rotator. In the drive device **2** of the present embodiment, the rotation of the motor **20** swings the up-down arm **21** and the driven arm **22**; the ends of the arms **21** and **22** slide under restriction by the channels **23** and **24** and are driven as an X link. This permits an up-down movement of the window glass **11**.

The motor **20** is provided with a rotation detection unit **27**; the rotation detection unit **27** is integrated into the motor **20** as one body. The rotation detection unit **27** outputs pulse signals (operating state detection signals), which is synchronized with rotation of the motor **20**, to the control circuit **3**. The rotation detection unit **27** is to detect a magnetic variation of the magnet rotated along with the output shaft of the motor **20** using a plurality of hall elements. Under such a configuration, the rotation detection unit **27** outputs the pulse signals in synchronization with the rotation of the motor **20**. That is, the pulse signals are outputted for respective predetermined movement quantities of the window glass **11** or respective predetermined angles of rotation of the motor **20**. Thereby, the rotation detection unit **27** can output the signals according to an operating state (i.e., movement) of the window glass **11**, which are approximately proportional to the rotation speeds of the motor **20**. Upon receiving the pulse signals from the rotation detection unit **27**, the control circuit **3** counts pulse edges of the pulse signals, and detects the position of the window glass **11** from a pulse count value. In the present embodiment, the rotation detection unit **27** and the control circuit **3** may thus function as an operating state detection section, means or device.

In the present embodiment, the rotation detection unit **27** includes the hall elements; however, there is no need to be limited thereto. As long as the rotation of the motor **20** is detectable, an encoder may be adopted. In the present embodiment, the rotation detection unit **27** is provided in the motor **20** so as to detect the rotation of the output shaft of the motor **20** according to the movement of the window glass **11**; however, there is no need to be limited thereto. The position of the window glass **11** may be directly detected by a well-known technology.

The control circuit **3** may be also referred to as a control device. The control circuit **3** of the present embodiment includes a controller **31** and a driver **32**. The controller **31** and the driver **32** receive electric power necessary for operation from a battery **5** mounted in the vehicle. The controller **31** of the present embodiment includes a microcomputer provided with a CPU, an input circuit, an output circuit, and memories such as ROM and RAM. The CPU is electrically connected with the memories, the input circuit, and the output circuit via a bus. The controller **31** may include a DSP (Digital Signal Processor) or gate array.

The controller **31** controls the motor **20** to rotate forward or reverse via the driver **32** based on a command signal (e.g., a close drive signal or an open drive signal) from the manipulation switch **4**, permitting the open-close movement of the window glass **11**. In addition, the controller **31** detects the position of the window glass **11** based on the pulse signal received from the rotation detection unit **27**, and adjusts the magnitude of the driving electric power provided to the motor **20** via the driver **32** depending on the detected position of the window glass **11**. To be specific, the magnitude of the duty ratio is adjusted when controlling the magnitude of the driving electric power or voltage or controlling PWM (Pulse Width Modulation) in order to adjust the output of the motor **20**.

The driver **32** includes an IC having FET (Field Electric Transistor), and switches the polarity of the electric power supply to the motor **20** based on an input signal from the controller **31**. That is, when receiving a forward rotation command signal from the controller **31**, the driver **32** provides electric power to the motor **20** so that the motor **20** rotates in the forward rotation direction. When receiving a reverse rotation command signal from the controller **31**, the driver **32** provides electric power to the motor **20** so that the motor **20** rotates in the reverse rotation direction. In addition, when a rotation stop command signal is received from the controller **31**, the electric power supply to the motor **20** is stopped. The driver **32** may switch the polarity using a relay circuit. In addition, the driver **32** may be incorporated or integrated into the controller **31**. In this case, the controller **31** may function as the control circuit **3**.

The controller **31** detects pulse edges that include rising portions and falling portions of pulse signals that are inputted, and calculates a rotation speed (rotational cycle) of the motor **20** based on intervals (cycles) of the pulse edges while detecting the direction of rotation of the motor **20** based on phase differences of the pulse signals. That is, the controller **31** calculates a movement speed of the window glass **11** indirectly based on the rotation speed (rotational cycle) of the motor **20**, and specifies the moving direction of the window glass **11** based on the direction of rotation of the motor **20**. In addition, the controller **31** counts the pulse edges. The pulse count value is subtracted or added in connection with the open-close movement of the window glass **11**. The controller **31** specifies the opening and closing position of the window glass **11** based on the magnitude of the pulse count value.

That is, the window glass **11** can be driven on a basis of the fully close position X1 defined as a reference position. When the fully close position X1 is defined as a reference position, the fully close position X1 corresponds to a pulse count value of zero "0". Thereafter, in cases that the window glass **11** moves toward one end (e.g., fully open position X2) of a moving area (movement segment), the pulse count value is incremented each time receiving a pulse signal. In contrast, in cases that the window glass **11** moves toward the other end (e.g., fully close position X1) of the moving area, the pulse count value is decremented each time receiving a pulse signal. Further, the fully open position X2 may be designated as a reference position, instead, to drive the window glass **11**. In this case, the fully open position X2 corresponds to a pulse count value of zero "0". When the window glass **11** moves toward the fully close position X1, the pulse count value is incremented. When the window glass **11** moves toward the fully open position X2, the pulse count value is decremented.

The manipulation switch **4** of the present embodiment includes, as a swing-type switch having two steps, an open switch, a close switch, or an auto switch; either switch is to operate an open-close member to open or close. When an occupant manipulates the manipulation switch **4**, the command signal for an up-down operation of the window glass **11** is outputted to the controller **31**. To be specific, when the manipulation switch **4** is manipulated to one end by one step, the open switch is turned on so as to output a usual open command signal to the controller **31**; the usual open command signal is for controlling the window glass **11** to perform a usual open movement, which is an open movement executed only during being manipulated, to move to an open state or open direction. In contrast, when the manipulation switch **4** is manipulated to the other end by one step, the open switch is turned on so as to output a usual close command signal to the controller **31**; the usual close command signal is for controlling the window glass **11** to perform a usual close movement, which is a close movement executed only during being manipulated, to move to a close state or close direction.

Further, when the manipulation switch **4** is manipulated to the one end by two steps, both the open switch and the auto switch are turned on so as to output an auto open command signal to the controller **31**; the auto open command signal is for controlling the window glass **11** to perform an auto open movement, which is an open movement to move to a position just prior to the fully open position X2 even after the manipulation is stopped or released. Further, when the manipulation switch **4** is manipulated to the other end by two steps, both the close switch and the auto switch are turned on so as to output an auto close command signal to the controller **31**; the auto close command signal is for controlling the window glass **11** to perform an auto close movement, which is a close movement to move to a position just prior to the fully close position X1 even after the manipulation is stopped or released.

While receiving the usual open command signal from the manipulation switch **4** (while the manipulation switch **4** is being manipulated), the controller **31** drives the motor **20** via the driver **32** to permit the usual open movement of the window glass **11**. In contrast, while receiving the usual close command signal from the manipulation switch **4** (while the manipulation switch **4** is being manipulated), the controller **31** drives the motor **20** via the driver **32** to permit the usual close movement of the window glass **11**. In addition, when receiving the automatic open command signal from the manipulation switch **4**, the controller **31** drives the motor **20** via the driver **32** to permit the automatic open movement of the window glass **11** to the position just before the fully open position X2. In contrast, when receiving the automatic close command signal from the manipulation switch **4**, the controller **31** drives the motor **20** via the driver **32** to permit the automatic close movement of the window glass **11** to the position just before the fully close position X1.

The controller **31** monitors whether a pinching by the window glass **11** occurs or not during the close movement of the window glass **11** (during the usual close movement or automatic close movement). That is, the occurrence of the pinching causes the decline of the moving speed (ascent speed) of the window glass **11** and the decline of the rotation speed of the motor **20** (the extension of the rotational cycle) that relates to the decline of the moving speed of the window glass **11**. Therefore, the controller **31** monitors the variation of the rotation speed of the motor **20** continuously. In the present embodiment, the controller **31** detects the start of the pinching based on the variation of the rotation speed of the motor **20** (that is, the ascent speed of the window glass **11**), and then determines the occurrence of the pinching (i.e., determines affirmatively the pinching) when detecting that the rotation speed varies by a predetermined quantity after detecting the start of the pinching.

Then, when determining affirmatively the pinching, the controller **31** performs a control with the pinching prevention function. That is, the controller **31** performs a pinching release control (open movement control) after determining the pinching; this release controls control the motor **20** to move reverse to release a foreign matter pinched by the window glass **11** to permit the window glass **11** to open by only a predetermined quantity. Further, when determining affirmatively the pinching, the controller **31** may stop the rotation of the motor **20** to stop the subsequent close movement of the window glass **11**, to thereby permit the release of the foreign matter pinched by the window glass **11**.

Further, the controller **31** is monitoring occurrence or nonoccurrence of trapping by the window glass **11** when the window glass **11** performs open movement (usual open movement and automatic open movement). That is, the occurrence of the trapping causes the decline of the moving speed (descent speed) of the window glass **11** and the decline of the rotation speed of the motor **20** (the extension of the rotational cycle) that relates to the decline of the moving speed of the window glass **11**. Therefore, the controller **31** monitors the variation of the rotation speed of the motor **20** continuously. The controller **31** detects the start of the trapping based on the variation of the rotation speed of the motor **20** (that is, the descent speed of the window glass **11**), and then determines the occurrence of the trapping (i.e., determines affirmatively the trapping) when detecting that the rotation speed varies by a predetermined quantity after detecting the start of the trapping.

When determining affirmatively the trapping, the controller **31** performs a trapping progress stop process in order to release a foreign matter trapped in between the window glass **11** and the belt moldings **13** and **14**; the trapping progress stop process is to control the supply of the electric power to the motor **20** to stop the movement of the motor **20** and the open movement (descent) of the window glass **11**. Reversing simply the movement of the motor **20** to raise the window glass **11** upon determining the trapping may cause a pinching between the window glass **11** and the upper portion of the window frame **12**. To that end, the occupant is permitted to release the trapping while confirming the situation. That is, the present embodiment operates as follows. While storing a state where a trapping progress stop process is activated upon determining a first occurrence of trapping, the controller **31** is provided to prevent re-occurrence (i.e., a second occurrence) of trapping during close movement after the first occurrence of trapping. Upon receiving a close movement command (i.e., close command signal) from the manipulation switch **4**, the controller **31** performs the following controls singly or in a combined manner to prevent the re-occurrence of trapping.

(1) Canceling a pinching prevention function;

(2) Prohibiting an automatic close movement by the automatic switch;

(3) Prohibiting a pinching release function to operate an open movement after detecting a pinching;

(4) Restricting an operating time (i.e., movement time) for a close movement;

(5) Restricting an operating quantity (i.e., movement quantity or length) for a close movement.

As explained above, the controller **31** specifies the opening and closing position of the window glass **11** based on the magnitude of the pulse count value.

The following will explain an outline of a process to determine trapping in the apparatus **1** with reference to FIGS. **4**A to **4**C. The controller **31** calculates a rotation speed ω of the motor **20** based on pulse signals received from the rotation detection unit **27**, and stores the calculated rotation speed ω of the motor **20**. FIG. **4**A illustrates a variation state of the rotation speed ω calculated in the above. The vertical axis of FIG. **4**A corresponds to a motor rotation speed; the horizontal axis corresponds to a pulse count. FIG. **4**A indicates an example of a state where the trapping decreases the rotation speed ω of the motor **20** from a middle time point. The data line A**1** indicates a state where a hard matter is trapped to decrease the rotation speed ω with a large deceleration; the data line B**1** indicates a state where a soft matter is trapped to decrease the rotation speed ω with a small deceleration. Further, in FIGS. **4**B and **4**C, the data lines A**2** and A**3** correspond to the state where a hard matter is trapped; the data lines B**2**, B**3** correspond to a soft matter is trapped.

The apparatus **1** according to the present embodiment performs a moving speed variation computation using a CPU (unshown). A rotation speed difference Δω is calculated based on the data of the rotation speed ω; the rotation speed difference Δω is a difference between the rotation speed ω at the present time and the rotation speed ω at the time before the present time by several pulse edges. That is, the variation of the rotation speed ω at the present time against the rotation speed ω at the previous time is calculated. The rotation speed difference Δω is equivalent to the rate of change in the rotation speed (moving speed) or equivalent to the variation of the rotation speed from the time before the present time by the several pulse edges. FIG. **4**B indicates the variation state of the rotation speed difference Δω. FIG. **4**A indicates that the absolute value of the rotation speed difference Δω of the data line A**1** is greater than that of the data line B**1**.

Now, the controller **31**, which may function as a trapping detection section to detect a start of trapping, determines whether the calculated rotation speed difference Δω exceeds a variation determination threshold α. When determining exceeding of the variation determination threshold α, the controller **31** determines that a trapping starts. In FIG. **4**B, the start of trapping is detected at the point P**1** or the point P**2**. However, the trapping is not determined at this time, so the motor **20** continues rotating and the window glass **11** continues descent (open movement). The variation determination threshold α is designated in the apparatus **1** such that a soft matter (for example, a lip portion of the belt molding) is trapped to cause the resultant rotation speed difference Δω exceeds the variation determination threshold value α.

Thus, once the start of trapping is detected, the controller **31** determines whether the accumulated value of the rotation speed difference Δω (that is, the variation value of the rotation speed ω) since detecting the start of trapping exceeds a trapping determination threshold β. When the variation value of the rotation speed ω exceeds the trapping determination threshold β, the trapping is determined. FIG. **4**C indicates a variation state of the accumulated value of the rotation speed difference Δω. The controller **31** determines the trapping (i.e., occurrence of trapping) when the accumulated value exceeds the trapping determination threshold β.

As explained above, the controller **31** determines the trapping when the accumulated value of the rotation speed difference Δω (that is, the variation value of the rotation speed ω) since detecting the start of trapping exceeds a trapping determination threshold β. Instead, the controller **31** may determine the trapping when the accumulated value of the rotation speed difference Δω for a predetermined period after detecting the start of trapping, or the accumulated value of the rotation speed difference Δω for a predetermined count (i.e., the rate of change in the rotation speed ω) exceeds the trapping determination threshold β.

As mentioned above, the apparatus **1** designates two thresholds. One variation determination threshold α is designated for the rotation speed difference Δω; the other trapping determination threshold β is designated for the variation of the rotation speed ω (i.e., total of rotation speed difference Δω). These two thresholds determine respective determination targets that are different from each other. In the present embodiment, the actual occurrence of the trapping is not determined by a duration or the number of pulse signals after the rotation speed difference Δω exceeds the variation determination threshold α. Trapping is determined based on the variation quantity of the rotation speed ω, which is calculated after the rotation speed difference Δω exceeds the variation determination threshold α.

Therefore, in the apparatus **1** of the present embodiment, when a foreign matter is trapped, the trapping load does not become greater. Trapping of a foreign matter may be determined while not providing a damage to the trapped foreign matter. In addition, even when a soft matter is trapped, the rotation speed difference Δω exceeds the variation determination threshold α in a comparatively early stage. When the variation value thereof thereafter exceeds the trapping determination threshold β, the trapping is determined. In this case, the trapped matter is a soft matter such as a lip portion of the belt molding; the rotation speed difference Δω does not become a small value (large as an absolute value). The accumulation of the rotation speed difference Δω starts once the variation determination threshold α is exceeded; thereby, when the accumulated value exceeds the trapping determination threshold β, the trapping can be determined certainly.

In addition, when a trapped matter is moderately hard, the apparatus **1** operates similarly to the case of the trapped matte being soft. That is, the accumulation of the rotation speed difference Δω starts once the variation determination threshold α is exceeded in a comparatively early stage; thereby, when the accumulated value exceeds the trapping determination threshold β, the trapping can be thus determined certainly. Thus, the apparatus **1** of the present embodiment can determine the trapping certainly under a small load, regardless of whether the trapped matter is soft or hard.

In addition, when the window glass **11** moves, the rotation speed of the motor **20** is influenced by sliding resistance or external factor even without occurrence of the trapping. Such influence may cause the rotation speed difference Δω to exceed the variation determination threshold α. Even in such a case, as long as the accumulated value of the rotation speed difference Δω does not exceed the trapping determination threshold β, the trapping is not determined. Even when the variation determination threshold α is set to a value for a soft matter being trapped, an erroneous determination is not made, and, rather, the start of trapping can be detected certainly.

In addition, the pinching determination by the power window apparatus **1** is operated similar to the trapping determination, and is thus omitted from the explanation. In a pinching determination, the controller **31**, which may function as a pinching detection section to detect a start of pinching, determines whether the calculated rotation speed difference Δω exceeds a variation determination threshold α'. When the variation determination threshold α' is exceeded, the start of pinching is determined.

The following will explain a flowchart of a trapping determination process and a trapping release process by the control circuit **3** or controller **31** with reference to FIG. **5**.

It is further noted that a flowchart in the present application includes sections (also referred to as steps), which are represented, for instance, as S**1**. Further, each section can be divided into several sections while several sections can be combined into a single section. Furthermore, each of thus configured sections can be referred to as a module, device, or means and achieved not only (i) as a software section in combination with a hardware unit (e.g., computer), but also (ii) as a hardware section (e.g., integrated circuit, hard-wired logic circuit), including or not including a function of a related apparatus. Further, the hardware section may be inside of a microcomputer.

First, when the controller **31** receives a usual open command signal or an automatic open command signal from the manipulation switch **4**, the controller **31** drives the motor **20** via the driver **32** to drive descent movement of the window glass **11** (S**1**). Then, the controller **31** updates a rotation speed data of the motor **20** first based on the pulse signals received from the rotation detection unit **27** (S**2**). To be specific, the controller **31** processes a pulse signal received from the rotation detection unit **27**, and detects a pulse edge. Each time detecting the pulse edge, a pulse width (time interval) T between (i) the pulse edge detected at the previous time and (ii) the pulse edge detected at the present time is calculated, and is stored one by one in a memory.

In the present embodiment, each time a new pulse edge is detected, the pulse width T is updated in order, and the newest four pulse widths T(0)-T(3) are stored. That is, when a pulse edge is detected, a new pulse width T(0) is calculated; the previous pulse widths T(0)-T(2) are shifted by one to be referred to as the pulse widths T(1)-T(3), respectively, and the previous pulse width T(3) is erased.

Then, the controller **31** calculates a rotation speed ω from the inverse number of the total (pulse cycle P) of the pulse widths T of n pulse edges serial in time. The rotation speed ω is a value proportional to the actual rotation speed. In the present embodiment, the (average) rotation speed ω(0) is calculated by the pulse widths T(0)-T(3) obtained from the present pulse edge and four previous pulse edges. Then, when the following pulse edge is detected, the rotation speed ω(0) is updated or replaced by the newly calculated pulse widths T(0)-T(3). At this time, the previous rotation speed ω(0) is stored as a rotation speed ω(1). Thus, the newest eight rotation speeds ω(0) to ω(7), which are updated each time a pulse edge is detected (with respect to each predetermined movement quantity or each predetermined rotation angle), are always stored in the controller **31**. Thus, calculating the rotation speed ω using more than one pulse width T permits (i) offsetting of dispersion in a sensor duty of each received pulse signal output, and (ii) calculation of the rotation speed whose error variation is offset.

Next, the controller **31** calculates a (average) rotation speed difference Δω (i.e., rate of change of the rotation speed) from the rotation speed ω (S**3**). To be specific, the rotation speeds ω(0)×ω(3) are referred to as the present block data; the rotation speeds ω(4)-ω(7) are referred to as the previous block data. The sum of one block data is subtracted from the sum of the other block data. That is, the rotation speed difference Δω is calculated by subtracting the sum of the rotation speeds ω(0)-ω(3) from the sum of the rotation speeds ω(4)-ω(7), and updated each time a pulse edge is detected (every predetermined movement quantity or every predetermined rotation angle). The sum of the calculated values may be divided by the number of data for obtaining the sum (four in the present embodiment). Thus, calculating the rotation speed difference Δω using more than one rotation speed ω can offset the phase difference between the rotation speeds ω.

Then, the controller **31** adds the calculated rotation speed difference Δω on a basis of a predetermined position of the window glass **11** serving as a reference position (S**4**). Each time the rotation speed difference Δω is calculated, it is accumulated; thereby, the difference of the rotation speed ω with respect to the reference position is calculated. Next, the controller **31** performs a determination process of a trapping start (S**5**). To be specific, when the rotation speed difference Δω exceeds the variation determination threshold α to the negative side, the start of trapping is determined (or detected). When not exceeding, the start of trapping is not determined. When the start of trapping is determined (S**5**: Yes), the controller **31** advances to S**7**. When the start of trapping is not determined (S**5**: No), an initial value is set to each of the accumulated value of the rotational speed difference Δω and the trapping determination threshold β (S**6**). To be specific, the accumulated value of the rotation speed difference Δω calculated at S**4** is set to a default variation amount So of the rotation speed ω, whereas the trapping determination threshold β is returned to a usual value that is not increased.

Then, the variation amount S of the rotation speed ω is calculated (S**7**). To be specific, the controller **31** subtracts the accumulated value of the rotation speed difference Δω calculated at S**4** from the default variation amount So of the rotation speed ω set at S**6** just before determining the start of trapping, thereby calculating the variation amount S of the rotation speed ω (accumulated value of the rotation speed difference Δω) after the start of trapping. This permits certainly the calculation of the variation portion of the rotation speed (i.e., trapping load) due to trapping.

In the present embodiment, the variation amount of the rotation speed ω after the start of trapping is calculated by calculating the difference of the variation amount from the reference value. There is no need to be limited thereto. When the start of trapping is not detected, the accumulated value of the rotational speed difference Δω may be initialized; when the start of trapping is detected, the accumulated value of the rotation speed difference Δω may not be initialized. This permits accumulation of the rotation speed difference Δω only after the start of trapping, thereby calculating the variation amount of the rotation speed ω.

Next, the controller **31** determines whether the variation amount S of the rotation speed ω calculated at S**7** exceeds the trapping determination threshold β (S**8**). When it is determined that the variation amount S of the rotation speed ω exceeds the trapping determination threshold β (S**8**: Yes), the drive of the motor **20** is stopped to stop the descent drive (i.e., descent movement) of the window glass **11** (S**9**). Subsequently, the controller **31** advances to a trapping release mode (S**10**), and ends the present process. In contrast, when it is determined that the variation amount S of the rotation speed ω does not exceed the trapping determination threshold β (S**8**: No), the present process is ended without advancing further.

The following will explain a first example of a process of a trapping release mode (S**10**) with reference to FIG. **6**. The present process is executed when the drive of the motor **20** is stopped after the trapping or the occurrence of the trapping is determined at S**8** of the trapping determination process in FIG. **5**. The trapping release mode is to prevent re-occurrence of trapping due to an erroneous operation of the pinching prevention function. The controller **31** executes a prohibition control to prohibit the automatic close movement of the window glass **11** and a cancellation control to cancel the pinching prevention function, whereas releasing trapping by driving the window glass **11** reversely if receiving a close command signal from the manipulation switch **4**.

First, the controller **31** prohibits the automatic close movement while canceling the pinching prevention function (S**21**). Here, S**21** starts (i) clock counting of a predetermined time t**1** and (ii) measuring of a predetermined distance L1, in order to restrict a duration during which the controller **31** continues (i) the cancelled state of the pinching prevention function and (ii) the prohibited state of the automatic close movement. The predetermined time t**1** is previously designated in a timer (unshown); the predetermined distance L1 is previously designated to correspond to a pulse count value and is stored in a memory such as ROM. When S**21** is executed, the controller **31** permits the timer to start clock counting while starting measuring of an ascent distance of the window glass **11** by incrementing or decrementing the pulse count value each time receiving a pulse signal.

Subsequently, it is determined whether the close switch of the manipulation switch **4** is turned on by determining whether a usual close command signal is received from the manipulation switch **4** (S**22**). When the close switch of the manipulation switch **4** is not turned on (S**22**: No), it is determined again whether the close switch of the manipulation switch **4** is turned on (S**22**). That is, S**22** is repeated until receiving a usual close command signal from the manipulation switch **4**.

When the close switch of the manipulation switch **4** is turned on (S**22**: Yes), the motor **20** is driven via the driver **32** to permit ascent movement of the window glass **11** (S**23**). The ascent movement of the window glass **11** enables the release of the trapping of the foreign matter. Subsequently, it is determined whether the close switch of the manipulation switch **4** is turned off by determining whether a usual close command signal from the manipulation switch **4** is stopped (S**24**). When the close switch of the manipulation switch **4** is not turned off (S**24**: No), it is determined that the manipulation switch **4** is still turned on; thereby, the motor **20** is ongoingly driven via the driver **32** to permit the ascent movement of the window glass **11** (S**23**). That is, S**23** and S**24** are repeated until detecting that the usual close command signal is stopped at S**24**. When the close switch of the manipulation switch **4** is turned off (S**24**: Yes), it is determined that the occupant can release the trapping of the foreign matter by the ascent movement of the window glass **11**. Thereby, the drive of the motor **20** is stopped via the driver **32** to stop the ascent movement of the window glass **11** (S**25**); then, the controller **31** returns to the trapping determination process in FIG. **5**. In addition, it may be determined that the predetermined time t**1** elapses since executing S**21** or that the ascent distance of the window glass **11** reaches the predetermined distance L1 due to the clock counting or the measuring of the ascent distance, which is started at S**21**. In such a case, the controller **31** releases the cancelled state of the pinching prevention function and the prohibited state of the automatic close movement of the window glass **11**.

At the process of the trapping release mode (S**10**), the controller **31** may execute a second example of the process in FIG. **7**, instead of the process in FIG. **6**. The present process in FIG. **7** is executed when the drive of the motor **20** is stopped after the trapping or the occurrence of the trapping is determined at S**8** of the trapping determination process in FIG. **5**. Similarly, the trapping release mode is to prevent re-occurrence of trapping due to an erroneous operation of the pinching prevention function. The controller **31** executes a prohibition control to prohibit the automatic close movement of the window glass **11** and a prohibition control to prohibit a pinching release operation (i.e., open movement) following detection of a pinching, whereas releasing trapping by driving the window glass **11** reversely if receiving an open command signal from the manipulation switch **4**.

First, the controller **31** prohibits the automatic close movement while prohibiting the pinching release operation (open movement) after detecting the pinching (S**31**). Here, S**31** starts clock counting of a predetermined time t**2** and measuring of a predetermined distance L2 in order to restrict a duration during which the controller **31** continues the prohibited state of (i) the automatic close movement and (ii) pinching release operation (open movement) after detecting the pinching. The predetermined time t**2** is previously designated in a timer (unshown); the predetermined distance L2 is previously designated to correspond to a pulse count value and is stored in a memory such as ROM. When S**31** is executed, the controller **31** permits the timer to start clock counting while starting measuring an ascent distance of the window glass **11** by incrementing or decrementing the pulse count value each time receiving a pulse signal. Subsequently, it is determined whether the close switch of the manipulation switch **4** is turned on by determining whether a usual close command signal is received from the manipulation switch **4** (S**32**). When the close switch of the manipulation switch **4** is not turned on (S**32**: No), it is determined again whether the close switch of the manipulation switch **4** is turned on (S**32**). That is, S**32** is repeated until receiving a usual close command signal from the manipulation switch **4**.

When the close switch of the manipulation switch **4** is turned on (S**32**: Yes), the motor **20** is driven via the driver **32** to permit ascent movement of the window glass **11** (S**33**). The ascent movement of the window glass **11** enables the release of the trapping of the foreign matter. Subsequently, it is determined whether a pinching occurs and whether the close switch of the manipulation switch **4** is turned off (S**34**). Here, when the rotation speed difference $\Delta\omega$ exceeds the variation determination threshold $\alpha 7$ to the negative side, the start of pinching is determined. When not exceeding, the start of pinching is not determined.

When no pinching occurs and the close switch of the manipulation switch **4** is not turned off (S**34**: No), the motor **20** is ongoingly driven via the driver **32** to permit the ascent movement of the window glass **11** (S**33**). That is, S**33** and S**34** are repeated until detecting that the pinching arises or that the usual close command signal is stopped at S**34**. When the pinching occurs or the close switch of the manipulation switch **4** is turned off (S**34**: Yes), the controller **31** determines as follows. The occurrence of the pinching may cause another foreign matter to be pinched in between the window glass **11** and the window frame **12** to pose a secondary incident or anomaly if the close movement is continued; otherwise, the occupant released the pinching of a foreign matter by the ascent of the window glass **11**. Thereby, the drive of the motor **20** is stopped via the driver **32** to stop the ascent movement of the window glass **11** (S**35**); then, the controller **31** returns to the trapping determination process in FIG. **5**. In addition, it may be determined that the predetermined time t**2** elapses since executing S**31** or the ascent distance of the window glass **11** reaches the predetermined distance L2 due to the clock counting or the measuring of the ascent distance, which is started at S**31**. In such a case, the controller **31** releases the prohibited state of the automatic close movement and the prohibited state of the pinching release operation (open movement) after detecting the pinching.

At the process of the trapping release mode (S**10**), the controller **31** may execute a third example of the process in FIG. **8**, instead of the process in FIG. **6**. The present process in FIG. **8** is executed when the drive of the motor **20** is stopped after the trapping or the occurrence of the trapping is determined at S**8** of the trapping determination process in FIG. **5**. Similarly, the trapping release mode in FIG. **8** is to prevent re-occurrence of trapping due to an erroneous operation of the pinching prevention function. The controller **31** executes a restriction control to restrict a movement quantity of the close movement of the window glass **11** and a cancellation control to cancel the pinching prevention function, whereas releasing trapping by driving the window glass **11** reversely if receiving a close command signal from the manipulation switch **4**.

First, the controller **31** executes a restriction process to restrict a movement quantity of the close movement (i.e., close movement quantity) while canceling the pinching prevention function (S**41**). The restriction process of the close movement quantity designates a predetermined time t to a timer (unshown); the predetermined time t corresponds to the close movement quantity by the reverse drive of the motor **20** at the time of detecting a trapping. The designated time t is stored in a memory such as ROM. Here, S**41** starts clock counting of a predetermined time t**3** and measuring of a predetermined distance L3 in order to restrict a duration during which the controller **31** continues the cancelled state of the pinching prevention function and the restricted state of the close movement quantity. The predetermined time t**3** is previously designated in a timer (unshown); the predetermined distance L3 is previously designated to correspond to a pulse count value and is stored in a memory such as ROM. When S**41** is executed, the controller **31** permits the timer to start clock counting while starting to measure an ascent distance of the window glass **11** by incrementing or decrementing the pulse count value each time receiving a pulse signal. Subsequently, it is determined whether the close switch of the manipulation switch **4** is turned on by determining whether a usual close command signal is received from the manipulation switch **4** (S**42**). When the close switch of the manipulation switch **4** is not turned on (S**42**: No), it is determined again whether the close switch of the manipulation switch **4** is turned on (S**42**). That is, S**42** is repeated until receiving a usual close command signal from the manipulation switch **4**.

When the close switch of the manipulation switch **4** is turned on (S**42**: Yes), the controller **31** starts clock counting of the timer and then drives the motor **20** via the driver **32** to permit ascent movement of the window glass **11** (S**43**). The ascent movement of the window glass **11** enables the release of the trapping of the foreign matter. Subsequently, it is determined whether the close switch of the manipulation switch **4** is turned off or whether the predetermined time t elapses based on the counted value of the timer (S**44**).

When the close switch of the manipulation switch **4** is not turned off and the predetermined time t does not elapse (S**44**: No), it is determined that the manipulation switch **4** is still turned on; thereby, the motor **20** is ongoingly driven via the driver **32** to permit the ascent movement of the window glass **11** (S**43**). That is, S**43** and S**44** are repeated until detecting that the close switch is turned off or that the predetermined time t elapses at S**44**. When the close switch of the manipulation switch **4** is turned off or the predetermined time t elapses (S**44**: Yes), the controller **31** determines that the occupant released the trapping of the foreign matter by the ascent of the window glass **11** or that the window glass **11** ascends for a time period sufficient to release the trapping of the foreign matter. Thereby, the drive of the motor **20** is stopped via the driver **32** to stop the ascent movement of the window glass **11** (S**45**); then, the controller **31** returns to the trapping determination process in FIG. **5**. In addition, it may be detected that the predetermined time t**3** elapses since executing S**41** or the ascent distance of the window glass **11** reaches the predetermined distance L3 due to the clock counting or the measuring of the ascent distance, which is started at S**41**. In such a case, the controller **31** releases the cancelled state of the pinching prevention function and the restricted state of the close movement quantity.

At the process of the trapping release mode (S**10**), the controller **31** may execute a fourth example of the process in FIG. **9**, instead of the process in FIG. **6**. The present process in FIG. **9** is executed when the drive of the motor **20** is stopped after the trapping or the occurrence of the trapping is determined at S**8** of the trapping determination process in FIG. **5**. Similarly, the trapping release mode is to prevent re-occurrence of trapping due to an erroneous operation of the pinching prevention function. The controller **31** executes a restriction control to restrict a movement quantity of the close movement (i.e., close movement quantity) of the window glass **11** and a prohibition control to prohibit the pinching release operation (open movement) after detecting a pinching while releasing trapping by moving the window glass **11** reversely upon receiving a close command signal from the manipulation switch **4**.

First, the controller **31** prohibits the restriction process of the close movement quantity while prohibiting the pinching release operation (open movement) after detecting the pinching (S**51**). The restriction process of the close movement quantity designates a predetermined distance L that corresponds to a pulse count value as the close movement quantity by the reverse drive of the motor **20** at the time of detecting a trapping. The designated value is previously stored in a memory such as ROM. Here, S**51** starts clock counting of a predetermined time t**4** and measuring of a predetermined distance L4 in order to restrict a duration during which the controller **31** continues the restricted state of the close movement quantity and the prohibited state of the pinching release operation (open movement) after detecting the pinching. The predetermined time t**4** is previously designated in a timer (unshown); the predetermined distance L4 is previously designated to correspond to a pulse count value and is stored in a memory such as ROM. When S**51** is executed, the controller **31** permits the timer to start clock counting while starting to measure an ascent distance of the window glass **11** by incrementing or decrementing the pulse count value each time receiving a pulse signal. Subsequently, it is determined whether the close switch of the manipulation switch **4** is turned on by determining whether a usual close command signal is received from the manipulation switch **4** (S**52**). When the close switch of the manipulation switch **4** is not turned on (S**52**: No), it is determined again whether the close switch of the manipulation switch **4** is turned on (S**52**). That is, S**52** is repeated until receiving a usual close command signal from the manipulation switch **4**.

When the close switch of the manipulation switch **4** is turned on (S**52**: Yes), the motor **20** is driven via the driver **32** to permit ascent movement of the window glass **11** (S**53**). Under the ascent movement, each time receiving a pulse signal, the pulse count value is incremented or decremented, the ascent distance of the window glass **11** is measured. The ascent movement of the window glass **11** enables the release of the trapping of the foreign matter. Subsequently, it is determined whether a pinching occurs and whether the predetermined distance L is exceeded (S**54**). Here, when the rotation speed difference $\Delta\omega$ exceeds the variation determination threshold α**7** to the negative side, the start of pinching is determined. When not exceeding, the start of pinching is not determined. In addition, when the incremented or decremented pulse count value during the ascent movement of the window glass **11** reaches the predetermined distance L, it is determined that the window glass **11** ascends by the predetermined distance L.

When no pinching occurs and the window glass **11** does not ascend by the predetermined distance L (S**54**: No), the motor **20** is ongoingly driven via the driver **32** to permit the ascent movement of the window glass **11** (S**53**). That is, S**53** and S**54** are repeated until detecting the occurrence of the pinching or the ascent of the predetermined distance L at S**54**. When a pinching occurs or the window glass **11** ascends by the predetermined distance L (S**54**: Yes), the controller determines as follows. The occurrence of the pinching may cause another foreign matter to be pinched in between the window glass **11** and the window frame **12** to pose a secondary incident or anomaly if the close movement is continued; otherwise, the window glass **11** ascends by a distance sufficient to release the trapping of the foreign matter. Thereby, the drive of the motor **20** is stopped via the driver **32** to stop the ascent movement of the window glass **11** (S**55**); then, the controller **31** returns to the trapping determination process in FIG. **5**. In addition, it may be determined that the predetermined time t**4** elapses since executing S**51** or the ascent distance of the window glass **11** reaches the predetermined distance L4 due to the clock counting or the measuring of the ascent distance, which is started at S**51**. The controller **31** releases the restricted state of the close movement quantity and the prohibited state of the pinching release operation (open movement) after detecting the pinching.

In the above embodiment, the variation determination threshold α and the trapping determination threshold β are maintained as the same values regardless of the position of the window glass **11**. There is no need to be limited thereto. Those thresholds may be changed depending on the position of the window glass **11**. Further, in the above embodiment, the trapping and the pinching are detected by the change of the rotation speed ω of the motor **20** calculated based on the pulse signal (operating state detection signal) received from the rotation detection unit **27**. Alternatively, such an operating state whether the window glass **11** contacts a foreign matter may be detectable based on the current value which flows into the winding of the motor **20** as well as based on the change of the velocity of the window glass **11** or the change of the rotation speed co of the motor **20**. For example, the occurrence of a pinching gives a load to the motor **20**, increases the electric current to the motor **20**, and decreases the voltage to the motor **20**. The controller **31** may investigate whether a variation of the electric current exceeds a threshold value, and investigate, when exceeding, whether the variation of the electric power exceeds a threshold value; thereby, the pinching can be detected. In this case, the current value or voltage value, which is outputted to the controller **31**, may correspond to an operating state detection signal. In addition, the above embodiment explains the open-close member control apparatus as the vehicular power window apparatus **1**. There is no need to be limited thereto. The open-close member control apparatus may be applied to another apparatus to drive an open-close movement of an open-close member such as a sunroof open-close apparatus or a slide door open-close apparatus.

While aspects of the disclosure described herein are already recited in the preceding summary, further optional aspects thereto may be set out as follows.

According to an optional aspect of the present disclosure, the restricted predetermined operation may include a pinching prevention operation which controls the open-close member to be driven reversely by operating the driving motor reversely when the pinching detection section detects a pinching of a foreign matter to the open-close member.

At the time of releasing the trapping, the pinching prevention function may malfunction because of the load change by the foreign matter having been trapped. The above configuration helps prevent the foreign matter having been trapped from being trapped again when the pinching prevention function malfunctions.

According to an optional aspect, the restricted predetermined operation may include a continuous drive operation of the open-close member to the close direction.

This configuration prevents the open-close member from continuing a close movement automatically irrespective of the situation of the trapping. This permits an occupant to control the release of the trapping using a close movement while confirming the situation of the trapping.

According to an optional aspect, the restricted predetermined operation may include a pinching release operation to drive the open-close member, which has been driven to the close direction, to the open direction.

At the time of releasing the trapping, a pinching may be erroneously determined because of the load change by the foreign matter having been trapped. The above configuration helps prevent the foreign matter having been trapped from being trapped again when a pinching release operation is activated following determining the pinching erroneously.

According to an optional aspect, the restricted predetermined operation may include a drive operation of the open-close member to the close direction for a time exceeding a predetermined operating time.

This configuration prevents the open-close member from continuing a close movement automatically irrespective of the situation of the trapping. This permits an occupant to control the release of the trapping using a close movement while confirming the situation of the trapping.

According to an optional aspect, the restricted predetermined operation may include a drive operation of the open-close member to the close direction by a distance exceeding a predetermined movement distance.

This configuration prevents the open-close member from continuing a close movement automatically irrespective of the situation of the trapping. This permits an occupant to control the release of the trapping using a close movement while confirming the situation of the trapping.

According to an optional aspect, the predetermined operation may be restricted until a predetermined time elapses or until the open-close member moves by a predetermined distance.

Under the above configuration, the pinching preventing function is recovered after the predetermined time elapses or the open-close member moves by the predetermined distance. This permits the detection of a pinching newly occurring after releasing the trapping.

While the present disclosure has been described with reference to preferred embodiments thereof, it is to be understood that the disclosure is not limited to the preferred embodiments and constructions. The present disclosure is intended to cover various modification and equivalent arrangements. In addition, while the various combinations and configurations, which are preferred, other combinations and configurations, including more, less or only a single element, are also within the spirit and scope of the present disclosure.

What is claimed is:

1. An opening and closing member control apparatus including an opening and closing member that moves in an open or close direction to at least partially open or close, respectively, an area within a window frame of the opening and closing member control apparatus,

the opening and closing member control apparatus comprising:

a driving motor which drives the opening and closing member in the open direction or the close direction;

a control circuit which controls operation of the driving motor;

a manipulation switch which outputs an open command signal or a close command signal to the control circuit, the open command signal indicating driving of the opening and closing member in the open direction, the close command signal indicating driving of the opening and closing member in the close direction,

the opening and closing member being either (i) driven only while the manipulation switch is manipulated or (ii) driven continuously once the manipulation switch is manipulated to a specified position regardless of whether the manipulation switch having been manipulated to the specified position is then released;

an operating state detection section which outputs an operating state detection signal according to an operating state of the opening and closing member that is driven in the open direction or in the close direction by the driving motor;

a trapping detection section which detects whether a foreign matter is trapped between the window frame and the opening and closing member, moving in the open direction, based on the operating state detection signal; and

a pinching detection section which detects whether another foreign matter is pinched between the window frame and the opening and closing member, moving in the close direction, based on the operating state detection signal,

the control circuit being further configured to restrict supplying an electric power to the driving motor to stop the opening and closing member moving in the open direction when the trapping detection section detects that the foreign matter is trapped, the opening and closing member moving in the open direction having been started based on the open command signal from the manipulation switch, and

to then supply the electric power to the driving motor to drive the opening and closing member in the close direction under a restricted state when receiving the close command signal from the manipulation switch after restricting supplying the electric power, the restricted state restricting a predetermined operation.

2. The opening and closing control apparatus according to claim **1**, wherein

the restricted predetermined operation includes a pinching prevention operation which controls the opening and closing member to be driven reversely by operating the driving motor reversely when the pinching detection section detects the pinching of a foreign matter.

3. The opening and closing member control apparatus according to claim **1**, wherein

the restricted predetermined operation includes a continuous drive operation of the opening and closing member in the close direction.

4. The opening and closing member control apparatus according to claim **1**, wherein

the restricted predetermined operation includes a pinching release operation to drive the opening and closing member, which has been driven in the close direction, in the open direction.

5. The opening and closing member control apparatus according to claim **1**, wherein

the restricted predetermined operation includes a drive operation of the opening and closing member in the close direction for a time exceeding a predetermined operating time.

6. The opening and closing member control apparatus according to claim **1**, wherein

the restricted predetermined operation includes a drive operation of the opening and closing member in the close direction by a distance exceeding a predetermined movement distance.

7. The opening and closing member control apparatus according to claim **1**, wherein

the predetermined operation is restricted until a predetermined time elapses or the opening and closing member moves by a predetermined distance.

8. A method for controlling an opening and closing member of an opening and closing member control apparatus, the opening and closing member moving in an open or close direction to at least partially open or close, respectively, an area within a window frame of the opening and closing member control apparatus,

the opening and closing member control apparatus including

a control circuit that controls the opening and closing member;

a driving motor that is also controlled by the control circuit to drive the opening and closing member in an open direction or a close direction;

a manipulation switch which outputs an open command signal or a close command signal to the control circuit, the open command signal indicating driving of the opening and closing member in the open direction, the close command signal indicating driving of the opening and closing member in the close direction, the opening and closing member being either (i) driven only while the manipulation switch is manipulated or (ii) driven continuously once the manipulation switch is manipulated to a specified position regardless of whether the manipulation switch having been manipulated to the specified position is then released;

an operating state detection section which outputs an operating state detection signal according to an operating state of the opening and closing member that is driven in the open direction or in the close direction by the driving motor;

a trapping detection section which detects whether a foreign matter is trapped between the window frame and the opening and closing member, moving in the open direction, based on the operating state detection signal; and

a pinching detection section which detects whether another foreign matter is pinched between the window frame and the opening and closing member, moving in the close direction, based on the operating state detection signal,

the method by the control circuit comprising:

restricting supplying an electric power to the driving motor to stop the opening and closing member moving in the open direction when the trapping detection section detects that the foreign matter is trapped, the opening and closing member moving in the open direction having been started based on the open command signal from the manipulation switch; and

supplying the electric power to the driving motor to drive the opening and closing member in the close direction under a restricted state when receiving the close command signal from the manipulation switch after restricting supplying the electric power, the restricted state restricting a predetermined operation.

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